

EXAMPLES

Example 1: Preparation of Oligonucleotide-Modified Gold Nanoparticles

A. Preparation Of Gold Nanoparticles

Gold colloids (13 nm diameter) were prepared by reduction of HAuCl₄ with citrate as described in Frens, *Nature Phys. Sci.*, **241**, 20 (1973) and Grabar, *Anal. Chem.*, **67**, 735 (1995). Briefly, all glassware was cleaned in aqua regia (3 parts HCl, 1 part HNO₃), rinsed with Nanopure H₂O, then oven dried prior to use. HAuCl₄ and sodium citrate were purchased from Aldrich Chemical Company. Aqueous HAuCl₄ (1 mM, 500 mL) was brought to reflux while stirring. Then, 38.8 mM sodium citrate (50 mL) was added quickly. The solution color changed from pale yellow to burgundy, and refluxing was continued for 15 min. After cooling to room temperature, the red solution was filtered through a Micron Separations Inc. 1 micron filter. Au colloids were characterized by UV-vis spectroscopy using a Hewlett Packard 8452A diode array spectrophotometer and by Transmission Electron Microscopy (TEM) using a Hitachi 8100 transmission electron microscope. Gold particles with diameters of 13 nm will produce a visible color change when aggregated with target and probe oligonucleotide sequences in the 10-35 nucleotide range.

B. Synthesis Of Oligonucleotides

Oligonucleotides were synthesized on a 1 micromole scale using a Milligene Expedite DNA synthesizer in single column mode using phosphoramidite chemistry. Eckstein, F. (ed.) *Oligonucleotides and Analogues: A Practical Approach* (IRL Press, Oxford, 1991). All solutions were purchased from Milligene (DNA synthesis grade). Average coupling efficiency varied from 98 to 99.8%, and the final dimethoxytrityl (DMT) protecting group was not cleaved from the oligonucleotides to aid in purification.

For 3'-thiol-oligonucleotides, Thiol-Modifier C3 S-S CPG support was purchased from Glen Research and used in the automated synthesizer. During normal cleavage from the solid support (16 hr at 55° C), 0.05 M dithiothreitol (DTT) was added to the NH₄OH solution to reduce the 3' disulfide to the thiol. Before purification by reverse phase high

pressure liquid chromatography (HPLC), excess DTT was removed by extraction with ethyl acetate.

For 5'-thiol oligonucleotides, 5'-Thiol-Modifier C₆-phosphoramidite reagent was purchased from Glen Research, 44901 Falcon Place, Sterling, Va 20166. The oligonucleotides were synthesized, and the final DMT protecting group removed. Then, 1 ml of dry acetonitrile was added to 100 μ mole of the 5' Thiol Modifier C₆-phosphoramidite. 200 μ L of the amidite solution and 200 μ L of activator (fresh from synthesizer) were mixed and introduced onto the column containing the synthesized oligonucleotides still on the solid support by syringe and pumped back and forth through the column for 10 minutes. The support was then washed (2 x 1 mL) with dry acetonitrile for 30 seconds. 700 μ L of a 0.016 M I₂/H₂O/pyridine mixture (oxidizer solution) was introduced into the column, and was then pumped back and forth through the column with two syringes for 30 second. The support was then washed with a 1:1 mixture of CH₃CN/pyridine (2 x 1 mL) for 1 minute, followed by a final wash with dry acetonitrile (2 x 1 mL) with subsequent drying of the column with a stream of nitrogen. The trityl protecting group was not removed, which aids in purification.

Reverse phase HPLC was performed with a Dionex DX500 system equipped with a Hewlett Packard ODS hypersil column (4.6 x 200 mm, 5 mm particle size) using 0.03 M Et₃NH⁺ OAc⁻ buffer (TEAA), pH 7, with a 1%/min. gradient of 95% CH₃CN/5% TEAA. The flow rate was 1 mL/ min. with UV detection at 260 nm. Preparative HPLC was used to purify the DMT-protected unmodified oligonucleotides (elution at 27 min). After collection and evaporation of the buffer, the DMT was cleaved from the oligonucleotides by treatment with 80% acetic acid for 30 min at room temperature. The solution was then evaporated to near dryness, water was added, and the cleaved DMT was extracted from the aqueous oligonucleotide solution using ethyl acetate. The amount of oligonucleotide was determined by absorbance at 260 nm, and final purity assessed by reverse phase HPLC (elution time 14.5 minutes).

The same protocol was used for purification of the 3'-thiol-oligonucleotides, except that DTT was added after extraction of DMT to reduce the amount of disulfide formed.

After six hours at 40°C, the DTT was extracted using ethyl acetate, and the oligonucleotides repurified by HPLC (elution time 15 minutes).

For purification of the 5' thiol modified oligonucleotides, preparatory HPLC was performed under the same conditions as for unmodified oligonucleotides. After purification, the trityl protecting group was removed by adding 150 µL of a 50 mM AgNO₃ solution to the dry oligonucleotide sample. The sample turned a milky white color as the cleavage occurred. After 20 minutes, 200 µL of a 10 mg/ml solution of DTT was added to complex the Ag (five minute reaction time), and the sample was centrifuged to precipitate the yellow complex. The oligonucleotide solution (<50 OD) was then transferred onto a desalting NAP-5 column (Pharmacia Biotech, Uppsala, Sweden) for purification (contains DNA Grade Sephadex G-25 Medium for desalting and buffer exchange of oligonucleotides greater than 10 bases). The amount of 5' thiol modified oligonucleotide was determined by UV-vis spectroscopy by measuring the magnitude of the absorbance at 260 nm. The final purity was assessed by performing ion-exchange HPLC with a Dionex Nucleopac PA-100 (4 x 250) column using a 10 mM NaOH solution (pH 12) with a 2%/min gradient of 10 mM NaOH, 1M NaCl solution. Typically, two peaks resulted with elution times of approximately 19 minutes and 25 minutes (elution times are dependent on the length of the oligonucleotide strand). These peaks corresponded to the thiol and the disulfide oligonucleotides respectively.

C. Attachment Of Oligonucleotides To Gold Nanoparticles

An aqueous solution of 17nM (150 µL) Au colloids, prepared as described in part A above, was mixed with 3.75 µM (46 µL) 3'-thiol-TTTGCTGA, prepared as described in part B and allowed to stand for 24 hours at room temperature in 1 ml Eppendorf capped vials. A second solution of colloids was reacted with 3.75 µM (46 µL) 3'-thiol-TACCGTTG. Note that these oligonucleotides are noncomplementary. Shortly before use, equal amounts of each of the two nanoparticle solutions were combined. Since the oligonucleotides are noncomplementary, no reaction took place.